R E P O R T R E S U M E S

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A STUDY OF THE RELATIVE EFFECTIVENESS IN TEACHING A MANIPULATIVE SKILL--A MULTIMEDIA TEACHING PROGRAM VERSUS CLASSROOM DEMONSTRATION WITH PRINTED INSTRUCTION SHEETS.

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THE PROBLEM WAS TO DETERMINE THE EFFECTIVENESS OF AN INDUSTRIAL ARTS PROGRAM PRESENTED TO COLLEGE-LEVEL LEARNERS, USING A MULTISTIMULI TEACHING MACHINE FOR TEACHING METAL SPINNING. IT WAS HYPOTHESIZED THAT INDUSTRIAL ARTS STUDENTS, WHEN PRESENTED A PROGRAM OF INSTRUCTION VIA A MULTIMEDIA DEVICE, WOULD ACHIEVE THE SAME DEGREE OF METAL SPINNING SKILL (AS MEASURED BY TASK COMPLETION TIME, AMOUNT OF METAL USED, AND CRAFTSMANSHIP QUALITY) AS SIMILAR STUDENTS TAUGHT BY A TRADITIONAL METHOD OF GROUP DEMONSTRATION, PRINTED INSTRUCTION SHEETS, AND A LIMITED AMOUNT OF INDIVIDUAL INSTRUCTION. PROGRAMED MATERIALS WERE PREPARED BY ANALYZING THE TASK OF SPINNING A FLARED ALUMINUM, ROLLED-EDGE BOWL. THE SUBJECTS WERE 20 METAL CRAFTS STUDENTS. TEN STUDENTS (CONTROL) RECEIVED THE TRADITIONAL DEMONSTRATION AND PRINTED INSTRUCTION SHEETS. THE OTHERS (EXPERIMENTAL) RECEIVED TOTAL INSTRUCTION VIA THE MULTIMEDIA DEVICE. BOTH GROUPS WERE OBSERVED ON THEIR METAL SPINNING TASK AS TO TIME CONSUMED (IN MINUTES), NUMBER OF TRIALS, AND INSTANCES OF SOLICITED ASSISTANCE. THE COMPLETED ALUMINUM BOWLS WERE THEN RATED ON QUALITIES OF FAITHFULNESS OF PROFILE, SMOOTHNESS OF SURFACE, AND NEATNESS OF ROLLED EDGE. AN ANALYSIS OF VARIANCE REVEALED THAT THE CONTROL GROUP CONSUMED SIGNIFICANTLY LESS TASK TIME THAN DID THE EXPERIMENTAL GROUP. IN ADDITION, THE CONTROL GROUP PREPARED HIGHER QUALITY BOWLS, BUT NOT SIGNIFICANTLY SO. TEACHING VIA THE MULTIMEDIA DEVICE CONSUMED MUCH MORE STUDENT TIME, BUT SIGNIFICANTLY LESS TEACHER TIME. (HB)

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A Study of the Relative Effectiveness in Teaching a Manipulative Skill – A Multi-Media Teaching Program versus Classroom Demonstration with Printed Instruction Sheets.

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A study of the Relative Effectiveness in Teaching a Manipulative Skill-- A Multi-Media Teaching Program versus Classroom Demonstration with Printed Instruction Sheets.

I. Introduction

The problem: The purpose of this study was to determine the relative effectiveness of a program presented to learners in a multiple stimuli teaching machine for teaching metal spinning, a typical industrial arts topic. Characteristically, the teacher of industrial arts spends a great deal of time providing individual instruction to students following the usual demonstration of a manipulative skill. It appears that when the student changes his position from viewer to operator, the change of orientation is sufficiently different to cause confusion and lack of confidence on the part of the student. In addition, the student apparently fails to grasp a great deal of what the demonstration intends to teach him due, perhaps, to the time lapse between observing and actually performing the manipulative operations. Sheffield points out (Lumsdaine, 1961) that with lengthy material conflicting memories or "inter-serial interference" is a common phenomenon.

Some of these same problems are encountered in industrial arts teacher preparation. If a properly programmed teaching machine can provide for the majority of the student's instructional needs on manipulative tasks, his instructor's effectiveness can be extended over a larger number of students. Such a device also provides for individual rates of progress in the instructional sequence.

As the nation's technology becomes more complex and more teaching units are added to the industrial arts curriculum, teachers must devise ways of making the most effective use of their class time. Industry has successfully used the auralvisual type machine to instruct factory workers to assemble intricate devices. (Fry, 1963, p. 35) It provides the assembler with a sequence of very specific directions which would be almost impossible to remember without the prompting of the machine. Here the machine is not teaching, but is used as an efficient "direction-giver".

The Audio-Graphic Machine used in this study provides, as the name implies, a learner with two media - sight and sound. The visuals are projected from the rear of a frosted plastic screen from standard 2 x 2 slides organized in a standard slide cartridge. The sound is transmitted through extremely light weight earphones, from a cartridge-type magnetic tape. Ultra sonic signals on the tape trigger the projection mechanism to either an advance or shut-down position. In the latter position, the operator (learner) must start the machine again. The operator (learner) may control the machine with either push buttons or foot pedals. The operator is not required to respond in advancing from frame to frame of the program. The machine is a cube about 16" x 16" x 16" and it is portable and operates on household current.

The Audio-Graphic device, in providing both audio and visual stimuli, suggests greater effectiveness than single mode devices, and greater efficiency than the usual instructor demonstration followed by individual help. McGuire (Lumsdaine, 1961) reported that sound on silent films provided "simultaneous

repetition" in a different modality without doubling the length of film. Fry (1963) points out that audio presentations permit the use of a larger vocabulary. In addition, the self-pacing feature provides for learner practice between sequences, which Sheffield claims adds considerably to program effectiveness. (Lumsdaine, 1961)

Lumsdaine (1960) and Stolurow (1961) both report that the Air Force has developed an "automated" projector for the training of motor skills. It entails the use of a magazine loaded endless loop sound motion picture film which can be stopped at will. An obvious disadvantage is the cost, which might have been the reason why Lear Manufacturing (Stolurow, 1961) developed a device which used a magazine tape and slide projector. It is apparently not too unlike the modified version of the Vidiosonic (Hughes Tool Co.) teaching machine used for factory assembly instruction (Fry, 1963).

Most of these devices have been used for relatively simple motor skills such as assembly and disassembly. The task proposed for this study required the teaching of a "feel", or the acquisition on the part of the learner of a kinesthetic sense which is presumbly developed with practice. Such practice requires "feedback" (Lumsdaine, 1961). The typical errors of metal spinning produce characteristic results which can be illustrated for the trainee. The remedy for these errors can be conveyed via audio and visual instruction.

Metal spinning is the process of converting sheet metal (aluminum, copper, bronze, etc.) into cylindrical shapes by using a lathe and spinning tools. In the spinning operation, the metal is shaped by pressing it over wood or metal forms as they are turned by the lathe.

Achievement in the skill of metal spinning can be evaluated in several ways. The first and most obvious is the time necessary for spinning an aluminum bowl. The second is the number of aluminum discs the learner uses to complete one bowl. The third is the quality of the finished product. Since this is, at least in part, a matter of judgment, a jury of experienced teachers rated the learner's bowl on a five-point scale. Characteristics such as surface quality, accuracy of profile, quality of trimmed edge, and accuracy of heights, are all observable qualities that were incorporated in the criterion.

The Hypothesis: It is hypothesized that college level industrial arts students, when presented a program of instruction via a multi-media devise (Audio-Graphic), will achieve the same degree of metal spinning skill as measured on three variables: the time required to complete, the amount of material used, and the quality of craftsmanship, as similar students taught by a traditional method characterized by group demonstration, printed instruction sheets, and a limited amount of individual assistance.

Plan of Study: In general, the plan for this study centers around a college level industrial arts metal crafts class; a required course in the industrial arts teacher training curriculum. One half of the class received instructions on how to spin an aluminum bowl through the traditional method of demonstration and printed instruction sheets. The remaining half of the class received programmed metal spinning instructions via the Audio-Graphic Instructor. The time consumed by each student-subject was recorded as well as the number of trials and instances of assistance. The quality of the bowls produced were rated by a panel of three judges.

The detailed description of the procedure followed in producing a phonotape articulated program for the Audio-Graphic appears in part II of this report. Part II also provides the details on the demonstration, designation of groups, and instructions and observation of the experimental and control groups.

Part III of this report deals with the treatment of the data collected, i.e. analysis of variance between groups, reliability of judges ratings, and inter-correlation between variables. The conclusions and implications drawn from this study appear in part IV. A number of appendices appear at the end of the report which contain examples of the instruments used, audio and graphic scripts, as well as instructions employed in the study.

II. PROCEDURE

Preparing the program. Although the planned program was to consist of a series of "still" pictures, the rules devised by Mays (1946) for filming motion picture demonstrations seemed most appropriate. The most significant rule stated that a filmed demonstration should be divided into a series of discrete steps or operational units. This is supported by Maccoby and Sheffield (1958) who found that short segments of demonstrations followed by practice were better than deferred practice required of large demonstration segments.

In order to identify operational units, a metal spinner was observed as he performed the steps necessary in spinning a flared aluminum rolled edge bowl, four and one half inches in diameter. When analyzed, it was found that the spinning task consisted of eight operational units. However, further analysis revealed that the skill of metal spinning required that the operator be able to remedy undesirable developments, i.e. 1) development of wrinkles 2) the scoring

of the surface and 3) tool breakthrough. In instances of wrinkles and scoring, remedial steps usually salvage the product. Break throughs, however, necessitate a fresh start. Two other units were also necessary.--one on personal safety and another on orientation to the machine which would facilitate subsequent instructions. The final sequence of the eleven operational units resulted in the following: 1) personal preparation (safety) 2) orientation to machine 3) centering spinning disc 4) forming the initial curve 5) tool positions and action 6) remedies for common faults 7) forming the flange 8) plannishing the surface 9) trimming the edge to size 10) rolling the edge and 11) polishing.

These operational units became the framework of the program. In order to illustrate them, a list of thirty-two picture descriptions was developed. It became the "script" that was used to direct the photographer who made approximately seventy-two exposures on 35mm Kodachrome film. Following the recommendations of Roshal (1961) and May (1946), zero camera angle, or as close to it as possible, was used. This seemed important because at the zero angle the learner sees the operation just as he does when he performs the operation. Also, parts were labeled in the pictures to facilitate subsequent instructions. As the photography work progressed, it seemed important that in five scenes the learner should not only see the tool in action, but should also see, in simplified form, what was happening to the metal. For this reason, bold line illustrations were made on 8½" x 11" white paper and pinned up on the backgrcund, but were clear to the viewer.

After the photographs were put into 2" x 2" slide transparency form, they were put in correct sequence in an Airequipt slide cartridge. The cartridge was then loaded into the Audio-graph[illegible] and its Programmer plugged in place. The Programmer is an accessory which has a microphone, a timing and stop dial, a button for a tone-signal, and a slide change button. After a phono-tape cartridge has been put into place the programming may begin.. Following a prepared script, the narrator recorded the instructions which corresponded to the projected visual. In the instructions the narrator called the learner's attention to visual cues as well as providing as many verbal cues as possible. The cues, plus repetition of important segments of instruction, according to May (1946), are necessary in filmed demonstrations.

As the visual appeared on the Audio-Graphics screen and the programmer provided the necessary narration, he pressed the slide change button for the next slide. This action put an ultra-sonic signal on the phonotape which in subsequent use automatically changed the slide. The narrator, upon finishing a slide sequence, which constituted an operational unit, would first press the warning tone signal. This signal warned the learner that the machine was about to stop and if he wanted to rewind the tape for a replay of the instructions he should depress the red floor pedal. The narrator allowed ten seconds between warning tone and dialing a stop. After the Audio-Graphic has stopped, the learner is required to carry out the instructions provided in the preceeding operational unit. The subsequent units are not presented until the learner reactivates the Audio-Graphic again by depressing the green floor pedal. The pacing within an operational unit is automatic, but the learner moves from one operational unit to another at his own speed. (For details of programming on the Audio-Graphic see Appendices A and B)

After the initial program was made, it was tried with two subjects not connected with the study and as a result two additional slides were added. Both were at the end of an operational unit sequence and served as examples of how the project should appear as a result of the operation. The tryout also revealed that the learner tended to try to work right along while the instructions were being given. This was remedied by adding instructions at the beginning of the program which cautioned the learner to wait until the instructions for each operational unit were complete.

The final program finally resulted in a series of thirty-four slide transparencies plus a title slide and fifteen minutes of verbal instructions via phonotape (Appendices A and B).

Group designation and scheduling. The subjects used in this study were teachers in training, none of whom had had experience with metal spinning. The experimental and control groups were randomly selected from the students enrolled in Metal Crafts 375, which is a required course in the industrial arts curriculum appearing in the junior year at The Pennsylvania State University. The laboratory time consisted of three 75-minute periods per week over a ten-week term. The process of metal spinning is normally taught as a part of the course.

Initially it was thought that the class could be broken up into two sections. However, it was found that a second section could not be scheduled because of conflicts in the students' schedules. There were eight students, four in the experimental group and four in the control group, who were willing and could come in at another time for the metal spinning work. This did two things

1) allowed more time for all students to perform the metal spinning task, and 2) provided an opportunity to investigate the effects of the noise distraction normally present in the laboratory. The control group, through necessity, were scheduled to work 5, 9, 12, 16, and 19 days after the demonstration. This arrangement provided an opportunity to check retention.

All the student subjects were asked to fill out a personal data form (Appendix C) which called for their names, age, weight, height, industrial experience, experience in operating a wood lathe, and their personal estimate of coordination. Strength of grip was recorded in class with a hand dynomometer. A preliminary study was initiated but could not be completed because of incomplete data. However, in the search for covariants, the Fuzak (1957) study held some promise in that strength of grip might correlate highly with ability to perform metal spinning. Another factor entered into each student-subject's record was Survey of Mechanical Insight, published by California Test Bureau.

The demonstration. The demonstration which was to be performed for the control group was organized around the eleven operational units developed for the programmed instruction (Appendix E). Instead of projected slide transparencies to support the verbalization, the demonstrator actually performed the sequence of steps required of the task. The simplified illustrations were also used to clarify the principles of tool action on the metal.

Near the end of the laboratory period the students were instructed to clean up and the students in the experimental group were dismissed. The remaining ten students were asked to remain for a demonstration on how to spin the bowl which was the required project. Physical conditions of heat, light, and venti-

lation were optimum and noise at a minimum. The students were arranged around the spinning lathe so that they could all see the demonstrator perform. The demonstrator performed the eleven operational units, cited earlier, at a pace that consumed fifteen minutes. There were a few questions which were answered. At the close of the demonstration, step by step instruction sheets were distributed. These were to serve as guides when they tried spinning an aluminum bowl (Appendix F).

Instructing and observing subjects. The following instructions were read to each subject at the time he was given a piece of material for spinning. (The experimental group received the same instructions on the Audio-Graphic).

1) Do not talk to other students during the metal spinning job.

2) Ask for help only when you can not proceed any further.

3) You will be observed, but do not let it disturb you because everyone is to be observed.

4) Do the best work you can do.

5) However, if you make an error, extra material is available.

Only the control group was told the following:

1) Have your instruction sheet handy.

2) Refer to your instruction sheet as often as you like.

Before the subjects in the experimental group were allowed to start work, they were read instructions on how to operate the Audio-Graphic (Appendix D). A color blind student had to be told that the left pedal was green and the right one red. In addition they were given a completed bowl which served as a model of how their finished bowl should appear.

For both groups, the observer was to record the actual time, in minutes, used by each subject in producing a spun bowl. Each subject was identified by a number which was later used to identify the bowl he had spun. The observer used a stop watch which he started when the subject actually began work. In the case of subjects taught by Audio-Graphic, the watch was stopped during the time they were receiving instructions. Therefore, all times recorded were actual working times. (Appendices I and J) The number of trials was also recorded as well as instances of solicited assistance.

Judging the products. The quality of the spun bowls was determined by a jury of three judges. They were selected because of their daily experience in teaching metal spinning in their industrial arts classes at the senior high school level. What was equally important was that they were engaged daily in evaluating student work.

The bowls to be rated were equally spaced on a table approximately 33 feet long. Each bowl rested on a sheet of paper upon which the student's number was printed. The judges, working separately, rated each bowl in terms of three factors on a five point scale. The first factor was faithfulness of profile. Each judge was supplied with a stiff paper template with which to judge this factor. Steel rules were also supplied for the purpose of checking the accuracy of height. The remaining two factors of neatness of edge and smoothness of surface were completely a matter of judgment.

A separate score sheet was provided for each bowl to be judged. Each judge then merely indicated his value judgment by checking off one of the number values on the five point scale for each factor. (Appendix H) Each set of score sheets was color coded in order to identify the judges later. For their services each judge was given $25.00 honorarium and travel expenses.

III Results and Treatment of Data

All the data were compiled in accordance with the proposed plan and are summarized in Table 1. (The raw data appear in Appendices I. and J.)

Table 1

Comparison of Mean Values of Variables Recorded

Group N	Time (in minutes)	Trials	Score	Assistance	Age	Height (in inches)	Weight (in pounds)	Grip	SMI	Ind. Exp. (in months)	Lathe Exp.	Coordination
Control 10	47.3	2.0	34.3	3.0	22.3	70.4	162	123	27.8	11.5	2.6	3.1
Experimental 10	89.2	2.7	26.0	0.6	22.5	70.4	169	126	29.7	22.1	2.1	3.0

Upon inspection it appears that the control group not only took less time, but also used less material and produced higher quality projects. In order to determine whether these differences were significant, the data were punched on 3 x 7 punch cards. The University's IBM 7040 computer was used to compute the intercorrelation between variables. A sizeable relationship could justify the use of a measure as an independent variable and covariant term.

Table 2

Intercorrelation Coefficients Between Variables

N = 20

	Time	Trials	Score	Age	Height	Weight	Grip	SMI	Ind. Exp.	Lathe Exp.	Coordin.
Time		.59	-.42	-.02	-.15	-.04	-.29	-.21	-.06	-.63	-.47
Trials			-.66	-.22	-.26	.05	-.32	-.21	-.15	-.19	-.42
Score				.26	-.20	-.45	.04	.21	.19	.18	.40
Age					.16	.04	-.08	.16	.75	-.05	.30
Height						.71	.30	-.18	-.08	.29	-.15
Weight							.38	-.22	-.15	-.06	-.43
Grip								-.16	-.28	.03	-.13
SMI									.34	.24	.42
Ind. Exp.										-.17	.53
Lathe Exp.											.29
Coordin.											

To be significant at the .05 level, a coefficient must be at least ±.43.

Since no really large relationship between time, trials, score, and any of the eight other variables was obtained (table 2), the data cards were programmed for analysis of variance and processed again. Tables 3, 4, 5, and 6 show that the time and assistance variables were the only measures that reached the level of significance. Although the control group's quality scores were quite a bit higher than the experimental group's, it merely approached, but did not reach significance. The hypothesis stated earlier was only partially disproved. There was a significant difference in favor of the control group with regard to the variable of time, but not trials or quality.

A review of Table 6 reveals that the demonstration or control group solicited assistance 29 times in comparison to 6 instances in the experimental group; this difference was found to be significant at the 1% level.

Table 3

Analysis of Variance for Time Variable

Source	df	Mean Square	F
Between groups	1	8778.0500	7.6450
Within groups	18	1148.2055	
Total	19		

Table 4

Analysis of Variance for Trials Variable

Source	df	Mean Square	F
Between groups	1	2.4500	1.4651
Within group	18	1.6722	
Total	19		

Table 5

Analysis of Variance for Score Variable

Source	df	Mean Square	F
Between groups	1	130.0500	3.4747
Within group	18	37.4278	
Total	19		

Table 6

Analysis of Variance for Assistance Variable

Source	df	Mean Square	F
Between groups	1	26.45	19.87
Within groups	18	1.33	
Total	19		

*Required F^1
5% Level=4.45
1% Level=8.40

[1]Snedecor, G. W. Statistical Methods, Ames, Iowa: Collegiate, 1937, pp. 174-177.

An opportunity to investigate the effects of time lapse between instruction and performance grew out of the necessity of scheduling the control group over a two-week period. Table 6 reveals no pattern or advantage of the earlier performers in comparison with a later one. Of course, the sample was admittedly very small.

Table 7

Comparison of Performance between With and Without Class Noise

Group	Means Time	Trials	Quality Score	N
Control With	44.5	2.3	33.1	6
Without	57.5	1.5	38.5	4
Experimental With	88.0	2.5	26.1	6
Without	91.0	3.0	25.7	4

Another factor that grew out of scheduling the subjects for use of the spinning lathe was that of distracting effect, if any, of noise upon the task of metal spinning. In the case of the experimental group, the effect of noise in learning from the Audio-Graphic (Table 7) provides no clear pattern or advantage. It appears, in fact, that the subjects in both groups who performed in the quiet shop consumed more time. Here again, the sample is extremely small.

Table 8

Scores of Control Group in Relation to Delayed Performance

Variables \ Days	5	9	12	16	19
Time	49.0	42.0	52.0	45	45
Trials	2.3	1.5	1.5	2	3
Score	33.0	39.0	37.5	31	30
N	3	2	2	1	2

Mean Values

In order to gain some indication of the inter-judge agreement of the judges' ratings, intercorrelations were computed. It should be noted that there is a relationship between the agreement and the opportunity for product variation, i.e., the profile is the easiest quality to evaluate while the rolled edge is the most difficult and requires the most skill.

Table 9

Correlations between Judge Ratings

Quality of Profile

Judge	II	III
I	.88	.76
II		.65

Surface Quality

Judge	II	III
I	.84	.56
II		.75

Quality of Rolled Edge

Judge	II	III
I	.63	.64
II		.52

IV Summary and Conclusions

Summary: It was hypothesized that college level industrial arts students when presented a program of instruction via a multi-media devise (Audio-Graphic), would achieve the same degree of metal spinning skill as measured on three variables: the time required to complete, the amount of material used, and the quality of craftmanship, as similar students taught by a traditional method characterized by group demonstration, printed instruction sheets, and a limited amount of individual assistance.

Conclusions: Except for the time required, the data collected support the hypothesis. An analysis of variance of the three variables measured revealed a significant difference in the case of time required to complete the spinning task. The traditionally-taught subjects of the control group consumed less time in completing the task. It should be pointed out that an analysis of variance revealed that this group also required significantly higher instances of teacher assistance. The control group in our sample, also tended to produce higher quality work, but this variable was not significant.

An analysis of the delay between instruction and performance, five to fourteen days, revealed no pattern favoring either extreme. Also, the noise distraction normally found in a metal crafts shop did not seem to adversely affect subjects in the control or experimental groups.

Implications: It seemed to the investigator that the subjects were unsure where the programmed instruction was taking them, although they had an example of a finished bowl in their hands. The experimental group agreed that the programmed instruction would have been an excellent review of a demonstration

immediately before performing. A typical remark was, "I wish I could have seen it done before I tried it".

On the basis of the reactions and remarks of the subjects in the experimental group, the following implications were drawn:

1. A program of instruction via phonotape articulated slide presentation lacks the action necessary for quickly learning a psychomotor skill.
2. The program, as prepared, did not provide and over all orientation to the task. The subjects moved from one operational sequence to another rather blindly.

Recommendations for further study:

1. Investigate the effects of a complete run through of the Audio-Graphic type program before the sequence of instruction begins.
2. Determine the value of an Audio-Graphic type program as a reinforcing technique only.
3. Compare the effectiveness of an Audio-Graphic type program with programmed instruction sheets which include photographs of each phase of printed instructions.
4. Compare the effectiveness of an Audio-Graphic type program with 8mm motion picture film loops, with sound, programmed in the form of single concept film cartridges for individual viewing. Such a program may provide the observation of action that subjects said they needed.

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Appendix

A--Metal Spinning Programmed Slide Sequence

B--Script for Metal Spinning Program on the Audio-Graphic

C--Personal Data Form

D--How to Operate the Audio-Graphic

E--Demonstration Lesson Plan

F--Metal Spinning Instruction Sheet

G--Observation Record Form

H--Judges Rating Form

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Appendix A

Metal Spinning Programmed Slide Sequence

Slide #	Code	Description	Unit #	Operational	Unit
1	T	Title	---	----	--
2 stop	S-1	Dressed Properly	I Personal Preparation		
3	A-1	Headstock Assembly			
4	A-2	Tool Rest	II Orientation to Lathe		
5	A-3	Chuck and Follower Block	II Orientation to Lathe		
6 stop	A-4	Tailstock Assembly	II Orientation to Lathe		
7	B-1	Putting disc in place	III Centering Disc		
8 stop	B-2	Set Speed & centering	III Centering Disc		
9	C-1	Applying Wax	III Centering Disc		
10	C-2	Starting Curve	IV Forming Initial Curve		
11	C-3	Side View-tool angle	IV Forming Initial Curve		
12 stop	C-4	Starting Curve	IV Forming Initial Curve		
13	D-1	Close-up of tool tip	V Tool Action		
14	D-2	Example of scored surface	V Tool Action		
15	D-3	Diagram of metal stretching	V Tool Action		
16 stop	D-4	Example - Tool breakthrough	V Tool Action		
17	E-1	Reset speed - 1000 rpm	VI Wrinkle Removal		
18	E-2	Spinning stage example 1	VI Wrinkle Removal		
19	E-3	Spinning Stage example 2	VI Wrinkle Removal		
20	E-4	Wrinkled Disc	VI Wrinkle Removal		
21	E-5	Positioning Backing Stick	VI Wrinkle Removal		
22	E-6	Final Step-wrinkle removed	VI Wrinkle Removal		

23 stop	E-7	Spinning Stage example 3	VI Wrinkle Removal
24	F-1	Spinning stage example 4	VII Forming Flare
25	F-2	Spinning stage example 5	VII Forming Flare
26 stop	F-3	Completely Flared Bowl	VII Forming Flare
27 stop	G-1	Plannishing - Inset Illust.	VIII Plannishing Surface
28	H-1	Straightening Flange	IX Trimming Edge
29	H-2	Trimming - Tool angle (side)	IX Trimming Edge
30	H-3	Trimming-zero angle	IX Trimming Edge
31 stop	H-4	Measuring Flange	IX Trimming Edge
32	I-1	Rolling Edge-Step 1	X Rolling Edge
33 stop	I-2	Rolling Edge-Step 2	X Rolling Edge
34 stop	J-1	Polishing Bowl	XI Polishing

Appendix B

Script for Metal Spinning Program on The Audio-Graphic

"This is Professor Shemick. I am going to be your metal spinning instructor today through this teaching machine which is called the Audio-Graphic Instructor. Before we start there are 5 items I should like to call to your attention.

1) Do not talk to your fellow students during this metal spinning job.
2) You are going to be observed while you do your metal spinning--don't be disturbed by this.
3) More material is available if you make a mistake and need to try again.
4) Do your best work.
5) Ask for help if you cannot proceed any further.

Now about the Audio-Graphic-- When you hear a tone signal like this (Beep) you may back up the machine by stepping on the red control pedal--you have just a few moments in which to do this--if you delay too long, you can not back up the machine.

A red signal light will appear when the Audio-Graphic is backed up as far as it will go.

To re-start it, step on the green pedal.

There will be times when the Audio-Graphic will stop to allow you time to work. In each case the machine may be started again by stepping on the green pedal.

Now on to the business of metal spinning!

Before we start working on any machine we must check for safety. We must always observe the rules of safety. Notice that I have my sleeves rolled up and that there are no rings or wrist watch. Most of all notice the safety glasses - <u>you must wear eye protection</u>. You must be dressed for safety <u>before</u> you start- see that all loose clothing is removed or tucked in, for example, ties and loose knit sweaters.

In a few moments the Audio-Graphic will stop. After you have checked yourself in light of the safety rules, and feel sure that you are dressed safely, step on the green control pedal for more instructions. (Warning tone. Ten second time interval. Dial stop.)

Let's move on now to the spinning lathe and become familiar with it. (Slide change)

The left hand part of the spinning lathe is called the head stock. This is where we control the speed. The numbers on the speed indicator dial are in RPMs. The hand wheel is for turning the lathe by hand, that is, when we want to inspect a piece in the lathe. Now let's look at the middle part of the lathe. (Slide change)

You will know this part of the lathe quite well before we are through. Notice that the fulcrum pins are loose. You will be moving them around later, as you use the metal spinning tools. Lever "L" locks and unlocks the tool rest assembly for positioning. Lever "M" locks and unlocks the tool rest to permit removal. (Slide change)

This is the chuck and follower block assembly. The chuck is the contour to which the metal is to be spun. The follower block holds the metal against the chuck. Different shaped chucks can be attached to the face plate. (Slide change)

This is the tailstock assembly. The hand wheel is used to move the follower block toward the chuck for holding the metal disc in position. The lever marked "lock" when tightened keeps the hand wheel from turning or working loose.

In a moment the Audio-Graphic will stop. After you have familiarized yourself with the parts just discussed--step on the green control pedal. You are not to work while the Audio-Graphic Instructor is in operation. You may go to work only at the end of each sequence of instructions. (Warning tone. Ten second time interval. Dial stop.) (Slide change)

You have been given an aluminum disc. To get it into the lathe first loosen the tailstock handwheel to allow the disc to slide in between the chuck and follower block. Second, tighten slightly, the hand wheel enough to hold disc in position. With head stock hand wheel, rotate chuck assembly. If seriously off center, re-position until it seems to be about on center. Position tool rest about 1" away from disc. (Slide change)

This is the centering operation. Set speed control at "start" position. Place centering stick, which you will find in tool rack on back of lathe, on tool rest firmly. Your thumb and finger should rest against tool rest. This is important because your fingers will hold the stick steady. Apply pressure with stick against disc as shown. Now loosen the tailstock handwheel slightly. Keep pressing the stick against disc until disc rides smoothly. You may have to rock the hand wheel to facilitate movement of the disc. Once centered, tighten hand wheel and lock in place with yellow locking lever on tailstock.

In a moment the Audio-Graphic will stop. If you have no questions proceed with centering the aluminum disc. When you have finished, step on the green control pedal. (Warning tone. Ten second interval. Dial stop). (Slide change)

The disc must be prepared for spinning. Apply wax, which you will find on tool rack on back of the lathe, to both sides of the disc. Keep the speed control at the "start" position. (Slide change)

Place a fulcrum pin, which you will find on the back of the lathe, in a hole of the tool rest so that it is about 1" to the right of the disc. Next take the round tipped tool with "B" on it from back of lathe. Tuck handle under the right arm. Turn tip so that round part faces the left. Hold tool tightly against fulcrum pin and tool rest with left hand. Right hand should grasp tool shaft behind left. (Slide change)

Put tool against the disc near the follower block and then pivot the rounded face of the tool against the disc. Keep the tool tip pressed against the disc. When you feel the metal yielding, then move the tool up and down until a small part of the disc takes on the shape of the chuck. Then stop the lathe for more instructions. Remember--keep the tool tip below center! (Slide Change)

In a moment the Audio-Graphic will stop. If you have no questions proceed with forming a small initial curve--then stop and step on the green control pedal. (Warning tone. Ten second interval. Dial stop) (Slide Change)

This is a reminder and an example of how the tool tip should be kept below center and the full face kept toward working surface. (Slide Change)

This is an example of improper tool angle--the operator held the handle of the tool down too low causing the tool tip to meet the spinning metal about on center. At this angle the tool scrapes rather than forms, thus causing a scored and torn surface. (Slide change)

This illustration shows how the spinning metal forms ahead of the spinning tool. If you move the tool in one direction only, you can over stretch the metal--so move the tool back and forth--such action will insure constant thickness.

The Audio-Graphic will stop in a few moments. If you have no questions, step on the green pedal. (Warning tone. Ten second interval. Dial stop.) (Slide Change)

To start the metal spinning operation set speed control at 1000--the indicator arrow should point to 1000. (Slide Change)

In the metal spinning process try to keep the metal in a bell shape. Do not allow outside edge to curve and extend back over rest of the spun metal. (Slide Change)

As you proceed, keep moving the fulcrum pin so that it is about 1" to the right of the outside edge; thus allowing proper application of the tool surface to the work surface. Notice that spun form to the right of the fulcrum pin is down on the chuck. (Slide Change)

Oh, Oh, this is what happens if you put too much pressure on the outside edge. Fortunately, it can be corrected. (Slide Change)

A backing stick can be found on the back of the lathe. Put another fulcrum pin in the tool rest so you can position the backing stick as shown in the picture. This is done at 1000 RPM for the lathe was stopped to show the process. With the back stick in place apply pressure to disc with rounded tool. In a pinching motion move from root of disc to outer edge. Remember you must get all the wrinkles out before proceeding or cracks will develop and spoil the project. (Slide Change)

This picture shows how to take the wrinkles out of the edge, thus completing the process. (Slide Change)

The machine will stop in a few moments. If you have no questions about taking out wrinkles, continue spinning until you are about half way through--about as far as I have gone in this picture. Then start the machine again for more instructions by stepping on the green control pedal. (Warning tone. Ten second interval. Dial stop.) (Slide Change)

Proceed with spinning as before--moving the fulcrum pin to keep the tool in correct position. (Slide Change)

Caution should be exercised here. If you do not follow the contour with face of the tool you may cut through with edge of tool. Stop spinning when the disc is touching and even with the shoulder of the chuck. (Slide Change)

This is an example of a good job--note that the edge is even and touching the chuck shoulder.

The Audio-Graphic will stop in a moment. Continue spinning until edge of disc is even with the chuck shoulder. Be sure the metal is down on the chuck and follows the contour. When finished, step on the green pedal. (Warning tone. Ten second interval. Dial stop.) (Slide Change)

This picture shows the planishing operation. Its purpose is to remove ridges that were formed during the spinning operation. Be sure there is enough wax on the metal. Use the flat surface of the turning tool. Move back and forth and keep checking for smoothness. It is often helpful to move the tool rest back away from the bowl thus allowing you more movement.

The Audio-Graphic will stop in a few moments. If you have no questions, proceed with planishing operation--when finished step on the green control pedal. (Warning tone. Ten second interval. Dial stop.)

The next sequence of illustrations is to show how to roll the bead on the spun bowl. Set the speed at 1200 RPM.

If the flange extends over the chuck shoulder, use fulcrum pin and backing stick, as shown, to straighten up. (Slide Change)

The first step requires that the edge be trimmed to the correct size. You will find the trimming tool marked "A" on the back of the lathe. This picture illustrates the correct way to hold the tool. Notice that the handle is held below the level of the tool rest. (Slide Change)

This picture further illustrates the correct use of the trimming tool. You may have to move the trimming handle up and down until you observe good cutting action, that is, small curly shaving rather than scrapings coming off the cutting edge. (Slide Change)

The edge of the bowl should be trimmed down so that it measures 7/16 of an inch from the flat part of the chuck to the edge of the flange. When down to size, touch the trimming tool to each side of the flange to remove the rough edge.

The Audio-Graphic will stop in a moment. If you have no questions proceed with the trimming operation and when finished step on the green pedal. (Warning tone. Ten second interval. Dial stop) (Slide Change)

The second step in rolling an edge is turning part of the flange back as shown. Use the backing stick to avoid scarring and marking the metal. This should not be a sharp turn but rather a rounded one. Notice that I use the tool rest as a pivot and the backing stick as a sort of pry. I find that I have more control this way and it takes less effort. (Slide Change)

The final beading step consists of changing the fulcrum pin so that the backing stick can be used to roll the edge completely under. You must coax the metal around---don't try to rush it. I have found that if I exert constant pressure on the forming bead and twist the backing stick, I get a rolling action that helps in forming. Keep the edge waxed too.

The Audio-Graphic will stop in a moment. If you have no questions, proceed with rolling the bead--when finished step on the green pedal. (Warning tone. Ten second interval. Dial stop.)

This picture shows the final operation. Remove tool rest; set speed at 2,000 RPM. Press pad (tuck in all loose ends) against bowl until luster appears. Be careful not to burn yourself because the bowl is revolving at a high rate of speed.

The Audio-Graphic will stop in a moment. If you have no questions, proceed with the polishing operation and when you are finished turn in your finished bowl to your observer."

Appendix C

Personal Data

Name _____

(Last) (First Initial)

Physical Characteristics

Age (closest birthday) _____

Height _____ft. _____inches.

Weight _____lbs.

Strength of grip _____lbs.

How would you rate your coordination: Excellent, Good, Fair, Poor (circle one)

Experience

1. Have you done any metal spinning before? Yes No (circle one)

   If yes, how long ago? _____ months

2. Have you worked in industry? Yes No (circle one).

   If yes, how long _____ months

   Was it a skilled job? Yes No (circle one)

3. Do you know how to operate and turn on a wood lathe? Yes No (circle one)

   If yes, how well? Excellent Good Fair Poor (circle one)

Appendix D

Instructions Read to Experimental Group

How to Operate the Audio-Graphic

1. You are one of the group chosen to learn metal spinning through the Audio-Graphic Instructor.

2. You start this machine with the switch marked "A". Once started, it will operate itself for the most part.

3. This machine provides instruction through a tape recording as well as through pictures projected on the screen.

4. You may hear the instructions through earphones by plugging in the earphone jack, or through the loudspeaker (its normal condition).

5. Caution: if you use the earphones the spinning lathe must be stopped while you do so.

6. The oral instructions will describe the pictures being projected on the screen. After a series of pictures have been shown, (this is automatic) the machine will stop itself so that you may perform the operation described.

7. If you do not understand, you may press the red colored foot pedal and the instructions associated with the last picture will "Play" again.

8. After you have performed the described operation, you start the machine again by stepping on the green colored pedal for the next sequence of instruction.

9. You may go through the whole program again if you feel the need to do so.

10. Do you have any questions?

Appendix E

Demonstration Lesson Plan

Instructional Materials

1. Sample bowl
2. Examples of failures
3. Spinning chuck
4. Turning tool
5. Trimming tool
6. Aluminum discs
7. Back sticks
8. Cloth
9. Wax
10. Line
11. Safety glasses
12. Shop coat

Introduction:

1. Metal spinning is a process that you all can learn if you follow directions.
2. Before you start you should tuck in any loose clothing, remove jewelry, roll up your sleeves, and wear safety glasses.

Presentation:

I Nomenclature

- A. Headstock Assembly
  1. spindle
  2. handwheel
  3. speed control
  4. chuck
- B. Tool Rest Assembly
  1. Tool rest
  2. Tool rest lock
  3. Tool rest assembly lock
- C. Tailstock Assembly
  1. handwheel
  2. locking lever
  3. follower-block

II Spinning Process

- A. Centering Disc
  1. Locate generally on center and tighten tailstock handwheel.
  2. Set speed on start position.
  3. Place centering stick on tool rest and apply pressure.
  4. Loosen tailstock handwheel-tighten when disc is centered.
- B. Initial curve
  1. Lubricate disc - wax.
  2. Position tool rest - one inch from disc.
  3. Position fulcrm pin - one inch right of disc.
  4. Place tool "B" left of pin - left hand holds on tool rest.
  5. Press round part of tool against root of disc.

C. Straight spinning and planishing
   1. Change speed to 1,000 RPM.
   2. Proper tool movement. (Show line Chart I)
   3. Continue moving fulcrum pins for best position.
   4. Tool should follow chuck contour.
   5. Stop spinning at shoulder of chuck.
   6. Back of turning tool for planishing. (Show Chart II)

D. Correction Procedures
   1. Removing wrinkles
      a. back stick
      b. second fulcrum pin

   2. Scored (scarred) surface
      a. holding tool too high.
      b. follow chuck contour
      c. lubricate - don't stay at one point too long.

   3. Breakthrough (Show line Chart III)
      a. back and forth tool action
      b. follow chuck contour

E. Rolling Edge and Polishing
   1. Straighten flange

   2. Trim edge - set speed at 1200 RPM
      a. use tool "a"
      b. keep handle low
      c. trim to 7/16"

   3. Turning Edge Back
      a. set fulcrum pin on left
      b. turn edge back to 45^{o} (Show Chart VI)
      c. roll under with twisting action (Show Chart VII)

   4. Polish
      a. make cloth pad
      b. remove tool rest
      c. move back and forth until luster appears.

Appendix F

Metal Spinning Instruction Sheet

TOOLS AND EQUIPMENT:

1 Metal spinning lathe
1 Chuck required for job
1 Round tip spinning tool (point tool)
1 Trimming tool
1 Hard wood stick about 12 x 1 - 1/2 x 3/4 inches
1 Block of wax or laundry soap

MATERIAL:

1 6-inch blank disk 18 gauge soft aluminum

PROCEDURE:

1. Check that the proper chuck is in the machine.
2. Insert the disk between the chuck and follower block.
3. Center the disk at slow speed and lock the tailstock.
4. Position the tool rest.
5. Lubricate the disk with wax.
6. Place fulcrum pin in rest and select spinning tool.
7. Advance the point tool against the base of the project.
   Note: Have the nose of the tool below the center of the work.
8. Use repeated short strokes and form the metal around the base of the chuck.
9. Increase lathe speed to 1,000 RPM.
10. Go back and forth using repeated short strokes.
11. Use the backing stick if wrinkle forms.
12. Continue working the metal toward the chuck, alternately working in opposite directions until the metal has been worked against the chuck.
13. Reposition tool, increase speed and trim the excess until there is 7/16 of an inch from the top of the disk flange to the flat of the chuck.
14. Planish the surface of the spun metal.
15. For the initial beading step turn back the flange 45°.
16. For the intermediate step roll the edge under.
17. Finish the beading operation.
18. Polish the bowl with a soft cloth at high speed. (remove tool rest)

CAUTION:

1. To guarantee the personal safety of the operator and prevent accidental injury certain safety procedures should be followed. Roll sleeves up above elbows. Tuck the tie inside of your shirt, and secure any other loose items of clothing that might become entangled with the operating lathe. Be sure to wear your safety glasses and remove jewelry.

Appendix G

Observation Record Form

DATE _____ SUBJECT _____

TIME STARTED _____

	Backups
CENTERING and SET-UP	
SPIN FORMING	
TRIMMING	
BEADING	

TIME FINISHED _____

Appendix H

Judges Rating Form

_____Subject

Spun Aluminum Bowl

	Lowest		(Circle score)		Highest
Faithfulness of profile. How well does the bowl conform to the chuck shape?	1	2	3	4	5

	Lowest				Highest
Surface Quality. How smooth, free from ridges and rough spots, is the surface?	1	2	3	4	5

	Lowest				Highest
Quality of Edge. How uniform, smooth, and rounded is the rolled edge?	1	2	3	4	5

Appendix I.

Control Group Data

Subjects	Time	Trials	Composite			Score	Assistance	Age	Height	Weight	Grip	SMI	Ind. Exp.	Lathe Exp.	Coordination
			Profile	Surface	Edge										
04	45	2	11	10	10	31	2	21	70	155	124	31	0	3	3
05	43	2	13	10	10	33	1	24	74	190	100	27	60	3	3
07	60	1	13	14	9	36	5	32	75	175	130	24	24	2	3
08	30	1	14	10	14	38	3	19	71	170	160	29	0	2	3
09	60	5	7	8	7	22	4	22	67	150	100	29	16	3	3
10	76	2	13	12	12	37	3	19	66	140	105	25	0	2	3
11	55	2	12	11	9	32	5	23	72	180	160	21	0	2	3
14	50	3	14	7	13	34	3	20	72	180	110	27	0	3	3
16	25	1	15	13	14	42	2	21	67	125	120	33	12	3	4
17	29	1	13	14	11	38	1	22	70	150	120	32	3	3	3
Mean Values	47.3	2.0	12.5	10.9	10.9	34.3	2.9	22.3	70.4	161.5	122.9	27.8	11.5	2.6	3.1

Appendix J.

Experimental Group Data

Subjects	Time	Trials	Composite				Assistance	Age	Height	Weight	Grip	SMI	Ind. Exp.	Lathe Exp.	Coordination
			Profile	Surface	Edge	Score									
01	87	2	14	12	11	37	0	34	68	145	111	34	144	2	4
02	132	3	7	6	7	20	2	19	70	170	112	24	0	0	3
03	131	5	14	9	7	27	1	21	72	160	118	28	0	3	3
06	60	4	6	9	3	18	2	20	70	185	138	29	9	2	3
12	177	4	12	10	10	32	1	22	66	155	110	30	0	0	2
13	85	3	12	11	5	28	0	20	73	180	140	26	0	3	2
15	67	2	15	8	10	20	0	21	68	155	140	26	20	3	3
18	80	1	4	9	11	24	0	22	77	190	130	33	3	3	3
19	35	2	14	8	10	18	0	25	70	200	140	34	18	2	3
20	38	1	12	15	11	36	0	21	70	148	122	33	36	3	4
Mean Values	89.2	2.7	11.0	9.7	8.5	26.0	0.6	22.5	70.4	168.8	126.1	29.7	22.1	2.1	3.0